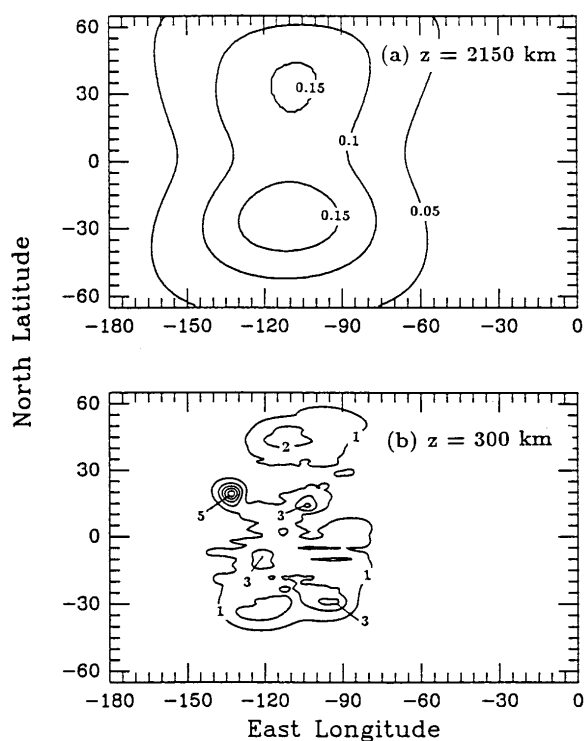


A CRUSTAL MAGNETIZATION MODEL FOR THE MAGNETIC FIELD OF MARS: A PRELIMINARY STUDY OF THE THARSIS REGION. L. L. Hood and K. Hartdegen, Lunar and Planetary Lab, University of Arizona, Tucson AZ 85721.

Small observational limits on the Martian magnetic dipole moment combined with scaling estimates from the terrestrial case make it unlikely that Mars has an intrinsic core-dynamo magnetic field at present [1]. However, a former core dynamo is allowed by thermal history models and it is known that Martian crustal materials contain abundant iron oxide remanence carriers including titanomagnetite [2,3]. It may therefore be hypothesized that a small crustal field exists whose origin is thermal remanent magnetization acquired during the period of Martian history when a core dynamo field was present [4,5]. Here, we report an initial quantitative investigation of this hypothesis by calculating expected field amplitudes above the Tharsis region assuming a source region consisting of uniformly magnetized volcanic constructs. The calculated amplitudes at 300 km altitude may be compared with observed amplitudes when data from the Mars Global Surveyor become available.

For the purpose of the present study, we adopt a model for the Tharsis region in which the elevated topography is due to the accumulation of volcanic material supported by a lithosphere whose rigidity increased with time [6]. As discussed in [6], subsidence of the Martian lithosphere in response to the volcanic load would result in a total thickness of volcanic materials that greatly exceeds the ~10 km topographic relief of the region. Assuming a constant-density crust, gravity and topography data imply a crustal thickness that is 35 to 50 km greater beneath the 10-km Tharsis dome than beneath adjacent regions [7]. Hence, the actual maximum thickness of volcanic units beneath Tharsis could be as large as 50 km. In order to estimate the maximum volume of a possible magnetic anomaly source region consisting of volcanically emplaced materials, we first estimated volumes above the 0-km altitude level within $5^\circ \times 5^\circ$ cells using a standard topographic relief map [8]. This was done separately for each cell and for that portion of each Amazonian geologic unit whose elevation exceeded 0 km. The resulting volume estimates compare favorably with more detailed volume determinations [9] when adjustments are made for differences in altitude of the assumed base plain.

We assume that the volcanic constructs comprising the Tharsis rise have bulk magnetization levels comparable to those measured for the SNC meteorites. After elimination of samples showing evidence for contamination by the terrestrial field during atmospheric entry, bulk magnetization intensities for shergottites and nakhlites are in the range $1\text{--}6 \times 10^{-5}$ emu/gm [2,3]. Assuming a mean mass density of 3 gm/cm^3 , the dipole moment per unit volume is $\sim 10^{-4} \text{ G-cm}^3/\text{cm}^3$. To compute the net magnetic field above the Martian surface, the field produced by the volume within each $5^\circ \times 5^\circ$ square was first calculated. This was done by representing the field source as a point dipole located at the center of each square at the 0 km elevation level. This procedure is a reasonable approximation at altitudes compara-



ble to or greater than the width of the cell (~290 km). For simplicity, the magnetization direction was assumed to be uniformly northward for all units. In effect, possible reversals of the Martian dynamo field during the emplacement of Tharsis volcanic constructs are neglected.

Figure 1 shows the calculated field magnitude at two different altitudes above the western hemisphere of Mars. The second altitude (300 km) was chosen to coincide roughly with the nominal altitude of Mars geophysical mapping missions (Figure 2b). At this altitude, the field is distinctly non-dipolar and maxima associated with individual surface units are discernible. In particular, the largest anomaly has an amplitude of 5 nT and is associated with Olympus Mons. While there are large uncertainties, the maximum field amplitudes shown in Figure 2b suggest that crustal field anomalies may be marginally detectable at an orbital altitude of 300 km during ionospherically undisturbed periods on the night side of the planet. Successful detection of crustal field anomalies associated with Tharsis volcanic constructs would confirm the inference from SNC meteorite studies of the former presence of a Mars intrinsic dynamo field. Later dating of anomaly sources as well as younger unmagnetized volcanic units would impose a quantitative constraint on the thermal evolution of the Martian interior.

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